Towards Pervasive Computing @ NIST

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Something fundamental is brewing...

- Increasing prevalence of mobile work, ad hoc teams and computers conversing with computers
- Growing numbers of embedded and mobile information appliances
  - *PDAs, cell phones, CrossPad, InfoPen…*
  - *Over 4 billion embedded processors sold per year*
- Rich and growing pico-cellular wireless technologies
  - *Bluetooth, HomeRF, 802.11, IrDA…*
  - *Bluetooth to produce a 9x9mm radio on a chip*
- Emerging technologies for dynamic service discovery
  - *Jini, Universal Plug-and-Play, Service Location Protocol…*
- Increasing use of Next-Generation Software Languages and Tools
  - *Java, Tcl, DCOM, JavaScript, REBOL…*

Leading towards new markets

- Health Care
  - Smart Hospitals and mobile doctors
- Education
  - Smart classrooms and campuses
  - More effective distance learning
- E-Commerce
  - Bring ubiquitous services to the customer
- Manufacturing
  - Flexible factory floor
- Mobile professionals
  - Computer-mediated meetings

Key defining properties

- Ubiquitous
  - Low-Cost
  - Embedded
  - Distributed
  - Non-intrusive
  - Innumerable

- Interconnected
  - Wired Core
  - Wireless Edge
- Dynamic
  - Mobile
  - Self-configuring

Barriers to creating a successful market

- Lack of widely accepted standards for service discovery, APIs, interoperability, pico-cellular wireless networks, automatic configuration and ad hoc transactional security…

- Lack of established infrastructure for self-organizing services and inter-domain security

- These issues will loom large over the IT industry for the next 5 years

The industry is asking for

- Standardization of testing and diagnostic tools
- Standardization of E-commerce services
- Standardization of APIs
- Better reference implementations
- Interoperability among diverse applications, services and devices

- Security assessments
- Robust capability-based security (hybrid RBAC?)
- Improved scalability
- Improved service discovery
- More open source
- Improvements in robustness and software quality

Source: http://www.jini.org

Why NIST?

- Market expansion requires industry-wide agreements on key technical standards
  - Need generic technical standards and interoperability
  - Current industry focus is on short-term, isolated, niche standards
  - NIST can work with industry to achieve a consistent vision and technical consensus
- NIST can provide:
  - Fair measurement tools and techniques to evaluate competing proposals for emerging technologies
  - Comprehensive public-domain reference implementations
  - Unbiased testing tools and suites to ensure product quality and conformance
  - Competent technical assessments of emerging standards and technologies

Some first steps

- Current:
  - Involvement with IEEE 802.15 and NCITS and working to define roles in IETF, the Jini community and other consortia
  - Collaborative projects such as AirJava/Aroma

- Proposed:
  - Develop multi-disciplinary AirJava/Aroma-based prototype demonstration(s) to explore standardization and technology issues and to attract interest from application sectors and outside sponsors

Existing collaborations with industry standards groups

- IEEE 802.15 Personal Area Networks
  - Closed Bluetooth specification being submitted
  - HomeRF consortium considering submission of specification
  - Technical evaluation of specifications and chairing co-existence subgroup
- NCITS R1 Committee
  - SDCT working with Java, UDI and real-time software
- Jini Community development process
  - SDCT and ANTD evaluating possible roles
- IETF Zero Configuration Working Group
  - ANTD evaluating possible roles
- Opportunities will also certainly exist for security standards
  - Security issues are a top priority in the Jini community

AirJava/Aroma

Claim: Within 5 years Systems-on-a-chip (SOC) costing $10 will include
- **pico-cell wireless transceiver**
- **virtual machine**
- **run-time environment**

▌ Goals - To discover technical and standards issues related to:

　▌ Connecting portable wireless devices to traditional networks

　▌ Service discovery, self-configuration and dynamic resource sharing

　▌ Mobile code and data

　▌ Software infrastructure needed to create and manage pervasive services and applications

AirJava Jini-based device adapter

- ***AirJava* adapter emulates tomorrow's SOC**
  - Low-power microcomputer and flash memory
  - 2.4 GHz wireless LAN PCMCIA Card
  - Linux or Windows
  - Java VM and Jini

- ***AirJava* adapter provides a platform for investigating challenges**
  - Managing and Exploiting Discovered Services
  - Security Mechanisms for Transient Users
  - Self-Organizing Mesh of Services
  - Logical Networking Context for Mobile Collaborators
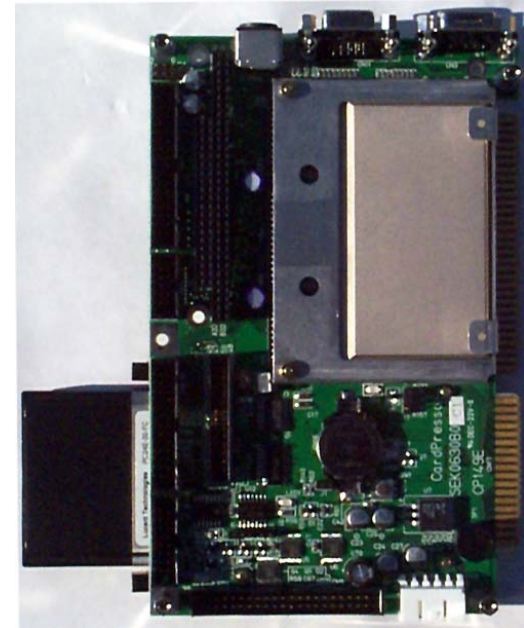
- **EPSON CARD 586**
  - **133 MHz, 48 MB RAM, 256 KB ROM, 1 MB Video Memory**
  - **Bus Controller, XGA Controller, FDC, COMBO Controller**
- **320 MB Flash Memory Card**
- **320x240 Pixel Color LCD**
- **2.4 GHz Wireless LAN PCMCIA Type II**

Aroma software infrastructure

- Develop software infrastructure, tools and techniques needed to create, manage, measure, test and debug pervasive services and applications
    - Address pervasive computing scripting issues using Java, Tcl, TclBlend, Feather
    - Develop measurement and diagnostic tools and techniques for pervasive services and applications
    - Specify services to support service discovery and query, and the APIs that all dynamically discovered services should support
    - Investigate the use of Java and the Uniform Device Interface (UDI) for writing platform-independent device drivers

Opportunities require investment

❚ Need hands-on experience:
  ❚ To identify key areas requiring standards
  ❚ To discover technology gaps
  ❚ To learn how to adapt existing approaches to conformance and testing
❚ Need cooperation across traditional boundaries
  ❚ Even within ANTD and SDCT, there is a need for collaborations across each division's groups for the AirJava/Aroma project
  ❚ Will require expertise in security, distributed systems, software, networking, and human-computer interaction
  ❚ Could benefit from collaborations with other labs - EEEL, MEL, ...
❚ Need to build and strengthen relationships with industrial players
❚ Need to entice key application segments

Prototype demonstration

- **Goal**: Create a 'simple' multi-division pervasive computing prototype that addresses key issues:
  - Develop a wireless "pervasive" projector using Java/Jini and AirJava adapters that would allow a notebook user to discover and use it without user configuration
- Relatively short-term and low-risk means to investigate pervasive computing issues
- Could lead to future collaborative efforts on larger and more complex efforts

Prototype demonstration

- Success requires multi-disciplinary approach
- Some issues that need to be addressed:
  - Networking
    - What is the minimal bootstrapping needed to discover devices and services and to configure a mobile computer to use them?
  - Software
    - What software infrastructure is needed to create pervasive computing applications?
  - Security
    - How do we control access to devices and services, given unknown users and dynamically changing user roles during collaborations?
  - Human Computer Interaction
    - What is the best way to access and present distributed information on arbitrary devices?
    - What is the best way for participants to interact during collaborations?

Near-term deliverables

- Pervasive Computing 2000 Workshop (January 25-26 at NIST)
- AirJava Adapter
- Pervasive Computing Software Tools
  - Feather
  - Jini services scripting
- Java/UDI Technical Proposal
- Prototype Demonstration
- Proposal for Larger Collaboration

Potential future collaborations

- Potential future multi-disciplinary collaborative projects:
  - Health Care
    - Help expand hospital use of PDAs and pervasive computing
  - Education
    - Partner with academia to explore pervasive computing in education
  - E-Commerce
    - Create NIST-wide multi-OU project with industry to address commercial uses of pervasive computing
  - Manufacturing
    - Create NIST-wide multi-OU project with industry to create smart spaces in manufacturing facilities
  - Mobile Professionals
    - Develop NIST locality-based information services such as a wireless projector application in the Red and Green auditoriums

Recap

- Industry movement toward pervasive computing is fundamental and long-term

- Industry is seeking help to address the significant standards and infrastructure barriers that must be addressed over the next five years

- NIST is positioning itself to play a vital role in the development of tomorrow's pervasive computing market

- More collaboration and larger-scale projects are both required and justified

What we recommend

■ Continue exploring opportunities to participate in the development of new pervasive computing standards

■ Develop short-term multi-division collaborative prototype demonstrations

    ■ To explore standardization and technology issues and

    ■ To attract interest from application sectors and outside sponsors

■ Create long-term multi-disciplinary, multi-OU collaborative projects in partnership with industry and academia